FIGS. 9A and 9B are schematic illustrations showing additional embodiments of pin position retention mechanisms for use with the tactile graphic array of this invention;

FIG. 10 is a diagrammatic illustration showing one means of pin position locking for use with the tactile graphic array of this invention;

FIG. 11 is a diagrammatic illustration showing a second means of pin position locking for use with the tactile graphic array of this invention;

FIG. 12 is a diagrammatic illustration of a roller for high speed vector drawing used in pin setting with the tactile graphic array of this invention; and

FIG. 13 is a partial sectional diagrammatic illustration of apparatus in accord with this invention.

DESCRIPTION OF THE INVENTION

The apparatus of this invention will be described with reference to the FIGURES. For use with the approaches taught herein, pins **21** as shown in FIG. **1** may be utilized. Pins **21** are oriented perpendicular to an extended reading (or sensing) surface **23** (such as illustrated in FIGS. **2** through **4** and **6**, and wherein hundreds of pins are utilized as a minimum), and are raised or lowered (moved perpendicular to the reading surface) to form the tactile graphic images. The portions of the pin that may be of interest are top portion **25** (the end that the user touches during the reading process), shaft **27**, and bottom portion **29** (the end that is always below the reading surface, that the user never touches). Top portion **25** of pin **21** must meet a number of performance requirements. It must allow smooth lateral motion of the reading fingers, and the shape must be chosen so that the pin does not feel unduly sharp, and so that the fingers are unlikely to catch on the edge of a pin when moving from an area where the pins are lowered to an area where the pins are raised. The shape of top portions **25** must also facilitate the user's ability to interpret a sequence of raised pins as a continuous line or curve rather than as a set of unrelated points.

Top portions **25** of pins **21** thus preferably include rounded heads **31** that are larger than shafts **27** of the pins, similar to the heads of round-headed nails. Heads **31** are relatively positioned at surface **23** of the display apparatus of this invention sufficiently close so that heads **31** of pins **21** nearly touch. This design permits a large radius of curvature of heads **31** relative to pin spacing to allow smooth finger motion and discourages fingers catching on the edges of raised pins, provided that the maximum displacement of adjacent rows of pins is less than the height of the rounded heads. Shafts **27** of pins **21** may still be relatively narrow, providing clearance for the action of the setting and locking mechanisms as hereinafter discussed.

Pin shafts **27** preferably include features to facilitate the action of the setting and locking mechanisms. Such features are desirable alternatives to purely friction-based mechanisms, which may be particularly prone to slippage and wear. Examples of such features include ridges or grooves **33** around the shaft. Grooves around the shaft are simple to implement in a blank shaft that is already at the desired diameter. Ridges around the shaft can be implemented by a screw machine or in a pressing operation, and do not significantly weaken the shaft. For both grooves and ridges, the shape and dimensions must be carefully chosen to interact properly with the operating mechanisms.

Bottom portions **29** of pins **21** are of interest only to the extent they play an active role in the operation of the display. In one embodiment of the apparatus of this invention, pins **21** are set by operation of the actuator against the bottom portions **29** of the pins, and the nature of the actuation requires a rounded pin tip **35** with radius of curvature equal to the radius of shaft **27**.

Several different pin array configurations could be utilized at surface **23**, configuration of the pin array chosen taking into account the needs of the intended applications as well as the simplicity of implementation. A uniform rectangular array of pins (as illustrated at FIG. **2**) is the most versatile, is easy to implement, and can be effectively driven by a wide variety of scanning mechanisms. A staggered array configuration (as illustrated at FIG. **3**) offers greater pin **21** density relative to the diameter of pin heads **31**, and thus produces a more realistic tactile reproduction of geometric forms than a rectangular array. The offset of the pins in such an array must be taken into account in the pin driving algorithm.

For specific applications, more complex (non-rectangular) array designs would be desirable. Referring to FIG. **4**, one particularly useful example, used for Standard Braille text, requires different dimensions for the spacing of dots within a Braille character **37**, for the spacing between Braille characters in a line, and for the spacing between lines **39** of Braille text. If a primary intended application of an extended tactile graphic array includes the display of Braille text (with or without graphics as a secondary application), then there would be an advantage to placing pins to exactly correspond to the dot positions in Braille text (utilizing pins **41** to somewhat fill in the matrix when it is being used for graphic applications). Such an array would be highly effective for displaying standard-dimension Braille text. Again, driving algorithms of greater complexity would of necessity be utilized.

In the apparatus of this invention, extended tactile graphic array requires the functions of setting pins **21**, retaining the pins in the desired configuration, and resetting pins **21**. A configuration of stacked elements is preferred to implement these functions. The overall display is designed in multiple layers **43** (shown in FIG. **5** laid side by side, it being understood that in operation the layers are stacked one atop the other and that more than two layers, depending on function, may be utilized), where each layer **43** performs one or a small number of specific display functions, and each layer **43** has a relatively simple mechanical configuration. Layers **43** are stacked together and pins **21** installed to form the completed display surface **23**. Registration of the layers can be assured by mounting all the layers **43** on shafts **44** that extend through all the layers **43** at openings **45**, or by inclusion of tongue and groove structures in some of the layers **43**, in the non-display areas of those layers. In cases where a layer **43** is required to move laterally with respect to the other layers **43** (for example, a locking layer), openings **45** that align that layer to alignment shafts **44** or tongue and groove structures can be elongated slightly, to permit just the necessary amount of lateral motion (as discussed hereinbelow) of that layer relative to the other layers (see enlarged openings **45'** relative to openings **45"** in FIG. **5**, for example).

In an extended array design where each pin actuator controls multiple pins, pin retention mechanisms are preferred to hold each pin **21** in place at times when an actuator is not driving it. One approach is pressure-based device (such as a spring clip) **51** as shown in FIG. **7**. The actuator chosen must exert sufficient force to move pin **21** against the force of the pressure-based device (e.g. spring clip) **51** exerted at ridge **33** of pin **21**, and the pressure-based device holds the pin in its new position firmly against shaft **27** and ridge **33** (enough to prevent it from being moved by the